The aim of this study was to evaluate the clinical outcomes of patients with posteromedial tibial plateau fractures treated by open reduction and internal fixation (ORIF) through a posteromedial approach. Thirty-six patients with posteromedial tibial plateau fracture underwent ORIF through a posteromedial approach and were retrospectively analyzed. Preoperative X-ray pictures and CT images were obtained. And there were 11 cases of posteromedial tibial plateau fracture and 25 cases of posteromedial and posterolateral tibial plateau fracture. All the patients were treated surgically with posteromedial approach. The clinical outcomes were assessed according to the Rasmussen knee function grading system.

The patients were followed-up for an average of 17.5 months (range, 12-32 months). All the fractures attained satisfactory reduction. No major complications were observed. According to the Rasmussen knee function grading system, the results were graded as excellent in 21 cases, good in 13 cases, fair in 2 cases. The rate of excellent and good results was 94.4%. The posteromedial approach in our opinion is the best option to treat the posteromedial tibial plateau fractures because it can provide direct visualization of the fracture site and avoid dissection of neurovascular bundle in the popliteal fossa area with minimal soft tissue injury.

Keywords : tibial plateau fracture ; posteromedial approaches ; internal fixation ; buttress plate.

INTRODUCTION

Posteromedial tibial plateau fracture is not rare in clinical practice. It has been underappreciated previously. With the popular application of computed tomography (CT) and three dimensional (3-D) reconstruction in assessment of tibial plateau fractures, increasing attention has been paid to the posteromedial tibial plateau fracture (1-6,8-11,15). This kind of fracture is very unstable, and it is often accompanied with obvious articular surface displacement (9). Most authors advocate open reduction and internal plate fixation (ORIF) for the treatment. Although a great deal of efforts have been made to develop surgical approaches to manage this kind of fracture in the past few decades, controversy still remains over the optimal surgical approach.
Several surgical approaches such as the anterior approach, the anteromedial approach, the posterior approach have been recommended. However, each technique has its shortcoming, such as damage of the soft tissues caused by dissection, obstructing exposure of fracture fragment, impairment of blood supply to the soft tissues, and risk of injuring the neurovascular structures \((2-5,8)\). In order to overcome these shortcomings, we attempted to use a posteromedial approach for the treatment when the posteromedial tibial plateau was involved. The aim of our study was to evaluate the clinical outcomes of our patients with posteromedial tibial plateau fractures through this approach.

**PATIENTS AND METHODS**

**Patients series**

A retrospective review of posteromedial tibial plateau fractures treated with a posteromedial approach from March 2005 to November 2011 was performed at our institution. This study was approved by the local ethics committee. The inclusion criteria were as follows: (1) posteromedial tibial plateau fracture which was demonstrated by CT scans, (2) treatment with ORIF through a posteromedial approach and (3) the patients who received follow-up postoperatively. Seven cases lost to follow-up were excluded from the study. A total of 36 patients met the inclusion criteria for analysis. There were 23 males and 13 females, with an average of 40.1 years (range, 21-70 years). The mechanism of injury was a road traffic in 19 patients, a fall from height in 10, a simple fall in 5, and a sports-related injury in 2 cases. Time from injury to surgery was 6.8 days in average (range, 2-16 days). Preoperative X-ray pictures and CT images were obtained. Based on the Schatzker classification \((1,2)\), there were 11 cases of posteromedial tibial plateau fracture (type VI) and 25 cases of posteromedial and posterolateral tibial plateau fracture (type V). Among these patients, anterior cruciate ligament (ACL) injuries resulted from avulsion of intercondylar eminence were seen in 19 cases, compartment syndrome occurred in 1 case and multi-systemic compound injuries presented in 7 cases.

**Surgical technique**

Under general anesthesia or continuous epidural anesthesia, the patient was placed in prone position with a high thigh pneumatic tourniquet applied. The knee joint was held slightly flexed by a bump under the ankle. A 6-8 cm longitudinal incision was made along the border of the medial head of Muscle Gastrocnemius muscle, ending at the level of the knee joint line. The lateral border of Muscle Semimembranosus and the medial border of Muscle Gastrocnemius were exposed by blunt dissection. After blunt dissection, the Muscle Semimembranosus was retracted medially and the medial head of Muscle Gastrocnemius was retracted laterally. Care must be taken not to injure the important neurovascular structures in the popliteal fossa area, which were located between the two heads of Muscle Gastrocnemius. To identify the superior border of Muscle Popliteus, incise the muscle and detach subperiosteally to expose the entire posteromedial fracture fragment (Fig. 1). If required for better exposure and placement of the plate, the tibial insertion of Muscle Semimembranosus could be dissected accordingly. For further distal exposure, the medial border of the Muscle Soleus also could be partially detached. Once the fracture site was clearly exposed, a good reduction could be achieved by hyperextension with axial traction and pushing the fragment with the assistance of a periosteal elevator. Kirschner wires were used for the temporary fixation and intra-operative C-arm fluoroscopy control was used to assess the reduction. Cannulated screws, buttress plates or reconstruction plates could be used for fixation. Screws were carefully measured to prevent penetration through the anterior tibial cortices. Correct plate fixation required 2-3 screws fixation distal to the fracture line. As for the associated ACL injury, reduction and fixation were performed under arthroscopic assistance.

**Fig. 1.** Schematic drawing of the posteriormedial approach between the Muscle Semimembranosus and the medial head of Muscle Gastrocnemius of right knee in prone position.
Postoperative treatment

The postoperative rehabilitation was started 2–3 days after surgery, including functional exercises of muscle quadriceps and ankle joint, and flexion/extension exercises of knee joint by using a continuous passive motion machine twice a day. Non-weight bearing under the assistance of crutches was permitted usually 5 days after surgery. Partial weight bearing was allowed 6 weeks after surgery, and full weight bearing was initiated at 3 to 5 months when union was obtained.

Assessment methods

The clinical outcomes were assessed according to the Rasmussen knee function grading system (12). Five parameters (pain, walking capacity, lack of extension, range of motion, and stability of the knee joint) were included for evaluation, each with a full score of 6 points. Based on the total score of each patient, the function was graded as excellent (≥ 27 points), good (20–26 points), fair (10–19 points), and poor (6–9 points).

RESULTS

The patients were followed-up for an average of 17.5 months (range, 12–32 months). All the fractures attained satisfactory reduction (Fig. 2a-f). There was no wound infection or necrosis, screw loosening or breakage of implant, nonunion, varus/valgus deformity, and fracture redisplacement. One patient experienced numb in the posteroinferior of the affected leg, and recovered completely after 3 months of conservative treatment. Based on the Rasmussen knee function grading system, the total scores were 24.5 ± 2.6 points in average (range, 13–30 points). The mean pain scores were 4.8 ± 0.3 points, mean walking capacity scores 5.3 ± 0.5 points, mean lack of extension scores 5.3 ± 0.7 points, mean range of motion scores 5.0 ± 0.8 points, mean stability of the knee joint scores 5.5 ± 0.2 points. And the results were graded as excellent in 21 cases, good in 13 cases, fair in 2 cases. The rate of excellent and good results was 94.4%.

DISCUSSION

In the past, most authors believed that posteromedial tibial plateau fracture was rare and difficult to treat (8). With the increasing use of CT scan and 3-D reconstruction in patients with tibial plateau fractures, it was found that this kind of fracture was not rare (2,9). In a study of Barei et al (2), a posteromedial fragment was observed in nearly one third of the bicondylar plateau fractures evaluated. Higgins et al (9) studied 111 CT scans of bicondylar tibial plateau fractures, and they found that 65 cases involved posteromedial tibial plateau fragments, with an incidence of 59%. Some authors believed that the posteromedial tibial plateau fragment resulted from the avulsion fracture of semimembranosus tendon insertion site due to the stress on the knee joint in hyperextension (1). However, we believe that it is a split fracture caused by the impact on the posterior plateau from the femoral condyle with the knee subjected to vertical or varus stress in flexed or semi-flexed position (4,16). And when the stress is violent or in combination with a torsional force, the tibia has a tendency to dislocate anteriorly from the femur, which may lead to the ACL injury.

The posteromedial tibial plateau fracture has several unique characteristics. The fracture fragment is relatively big. Barei et al (2) found that the surface area of fracture fragment was 58% (19–98%) of the medial plateau surface and 23% (8–47%) of the entire plateau articular surface. Higgins et al (9) revealed that the average area of bone fragment was 25% of entire tibial plateau articular surface. The sagittal angle of fracture fragment is large and the displacement of articular surface is usually more than 5 mm (9,15). For these reasons, this kind of fracture is very unstable so that the conservative treatment is difficult to obtain stability after fixation. The posteromedial tibial plateau fracture is a vertical split fracture not a compression fracture, even in the osteoporotic patients. It was often associated with the ACL injury. In this study, there were 19 cases of avulsion fractures of the ACL tibial insertion, with an incidence of 53%. Reduction and fixation could be performed in one-stage surgery under arthroscopic assistance. For the complete ACL tear, second-stage reconstruction following fracture healing was recommended. As for the meniscal tear, arthroscopic suture repair or partial meniscectomy was recommended. Arthrotomy was not necessary in most cases for the exposure and...
Approach for the treatment of 8 patients with posteromedial tibial plateau fractures. They believed that the anteromedial approach can avoid injuries to the neurovascular structures in the popliteal fossa area, flexion contracture of the knee joint and other complications. However, semitendinosus and semimembranosus muscles obstructed the anteromedial approach. When stripping posteriorly, it was also easy to injure the medial collateral ligament. And the possible disturbance of blood supply to the soft tissues would increase, especially when the soft tissues around the knee had suffered high energy injury. Because the posteromedial tibial plateau approach for the treatment of 8 patients with posteromedial tibial plateau fractures. They believed that the anteromedial approach can avoid injuries to the neurovascular structures in the popliteal fossa area, flexion contracture of the knee joint and other complications. However, semitendinosus and semimembranosus muscles obstructed the anteromedial approach. When stripping posteriorly, it was also easy to injure the medial collateral ligament. And the possible disturbance of blood supply to the soft tissues would increase, especially when the soft tissues around the knee had suffered high energy injury. Because the posteromedial tibial plateau

Fig. 2. — A 33-year-old female patient with left posteromedial and posterolateral tibial plateau fracture. a,b. Preoperative X-ray pictures of anteroposterior and lateral views.
How to stabilize the posteromedial tibial plateau fracture remains controversial. Hsieh et al \(8\) placed lag screws from anterior to posterior for fixation of posteromedial tibial plateau fracture in 8 cases and the results were satisfactory. But most authors believed that it was prone to loss of reduction with the only use of lag screws when the fracture fragment was big \(3,11\). Gosling et al \(7\) demonstrated that lateral locking screw plate could provide stabilization of the medial fracture fragment. However, the directions of screws were predetermined based on the design of the plate. The screws were usually in parallel with the fracture line of posteromedial fractures. 

Fracture fragments are located posteriorly, some authors used posterior approach, such as described by Trickey in the 1960s, which were more demanding and involved dissection of the neurovascular bundle \(4,14\). This would increase the difficulty and risk of operation. In order to protect the neurovascular structures, Bendayan et al \(3\) described a posteromedial second incision to reduce and stabilize a displaced posterior fragment. Direct visualization and satisfactory reduction were achieved. However, this technique required splitting the medial head of Muscle Gastrocnemius, which would result in injury to this muscle.

\(c,d\). Preoperative 3D CT reconstruction images of lateral and posterior views.
medial limited contact dynamic compression plate fixation, lateral locking plate fixation and posterior T-buttress plate fixation for the posteromedial tibial plateau fracture. It was confirmed that the posterior T-buttress plate fixation was biomechanically the most stable in-vitro fixation method for posteromedial tibial plateau fracture. To date, many satisfactory results of posterior buttress plate fixation in clinical practice were reported (4,6,11). The results of our study were also satisfactory. There was no fragment (3). Therefore, satisfactory fixation cannot be achieved. In a biomechanical study, Yoo et al (15) revealed that posteromedial tibial plateau fracture fragments tolerated higher loads by using the lateral 3.5-mm conventional non-locking proximal tibial plate and posteromedial 1/3 tubular plate fixation. The fixation of fracture fragment by placement of the lateral locking screws was unreliable and the rate of failure was very high. Zeng et al (16) compared anteroposterior lag-screws fixation, anteromedial limited contact dynamic compression plate fixation, lateral locking plate fixation and posterior T-buttress plate fixation for the posteromedial tibial plateau fracture. It was confirmed that the posterior T-buttress plate fixation was biomechanically the most stable in-vitro fixation method for posteromedial tibial plateau fracture. To date, many satisfactory results of posterior buttress plate fixation in clinical practice were reported (4,6,11). The results of our study were also satisfactory. There was no

\[\text{ef. Postoperative X-ray pictures of anteroposterior and lateral views showed the posteromedial tibial plateau fracture was anatomically reduced and stabilized with a buttress plate.}\]

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internal fixation failure or fracture redisplacement. Nevertheless, the buttress plate is difficult to accurately shape and fit to the fracture site because the outline of the posteromedial tibial plateau is irregular and the transition zone of metaphysis has a great curvature.

In conclusion, the posteromedial approach is in our opinion the best option to treat the posteromedial tibial plateau fracture because it can provide direct visualization of the fracture site and avoid dissection of neurovascular bundle in the popliteal fossa area with minimal soft tissue injury. As a result, satisfactory reduction, stable internal fixation and good functional outcomes can be attained by using this technique.

REFERENCES
